Morphos Modeling of Nearshore Morphology and Data Needs

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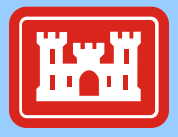
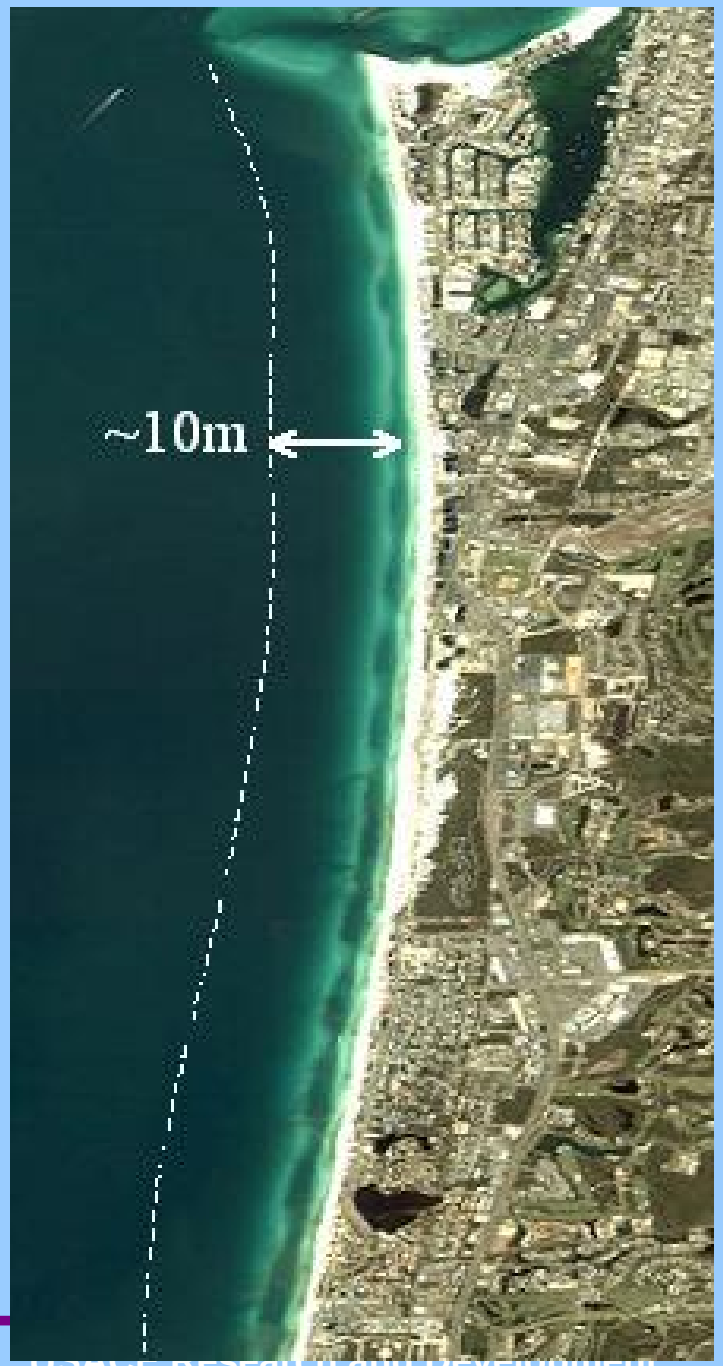
- Overall approach
- The spectrum of efforts
- Dutch approach and results (Xbeach)
- CHL/U. Delaware
  - CSHORE approach and results
  - C2SHORE results
- Data needs to drive modeling

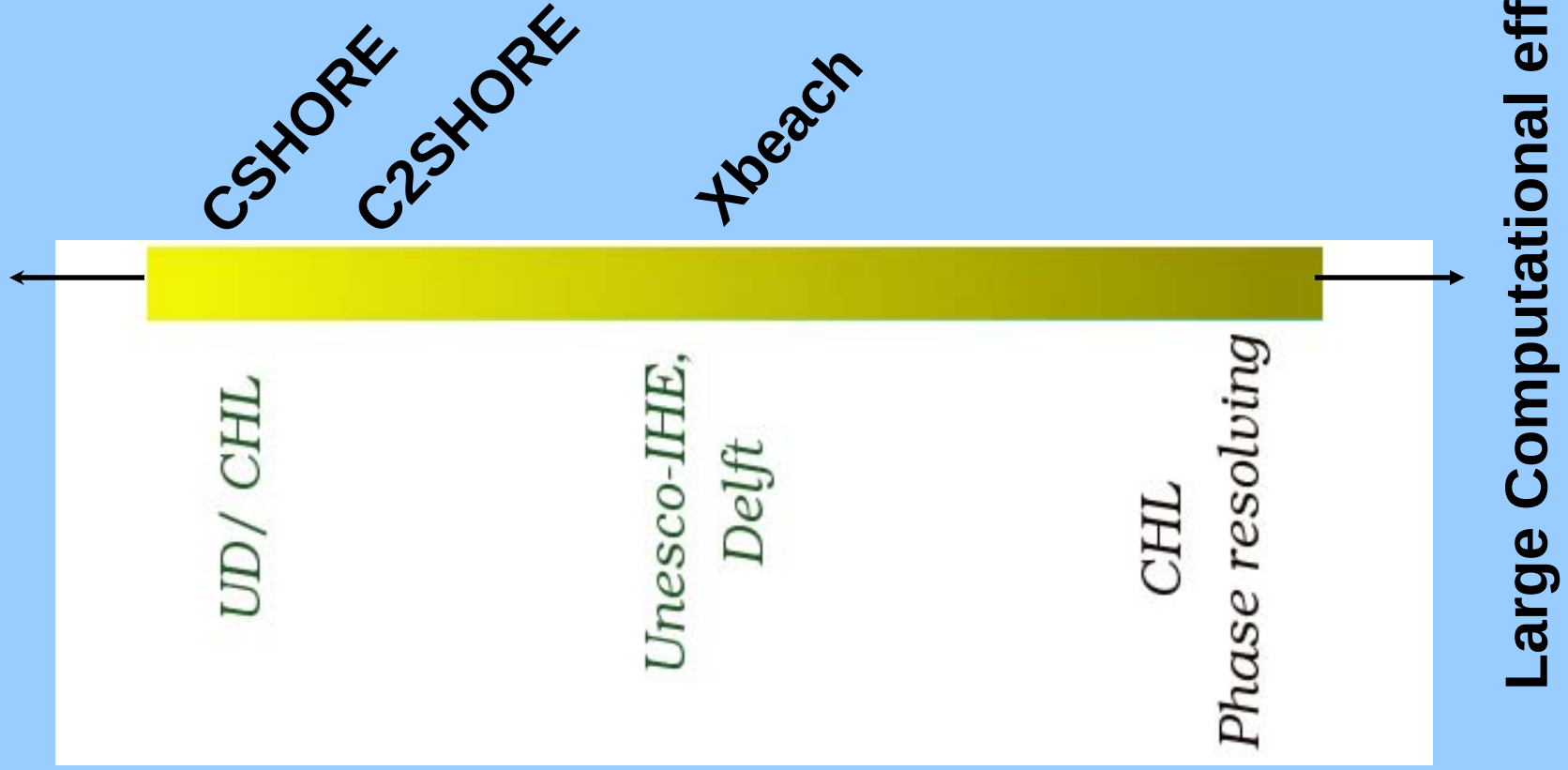


Approach

- **Use open-water surge/current and wave models or data to drive nearshore FD model**
- **Nearshore model domain: depth of morphology change through dune and beyond**
- **Various approaches/levels of modeling to assure we have the appropriate set of tools to address project goals**



Spectrum of Efforts



- CSHORE: profile development
- C2SHORE: 2DH quasi-steady
- Xbeach: low frequency resolving

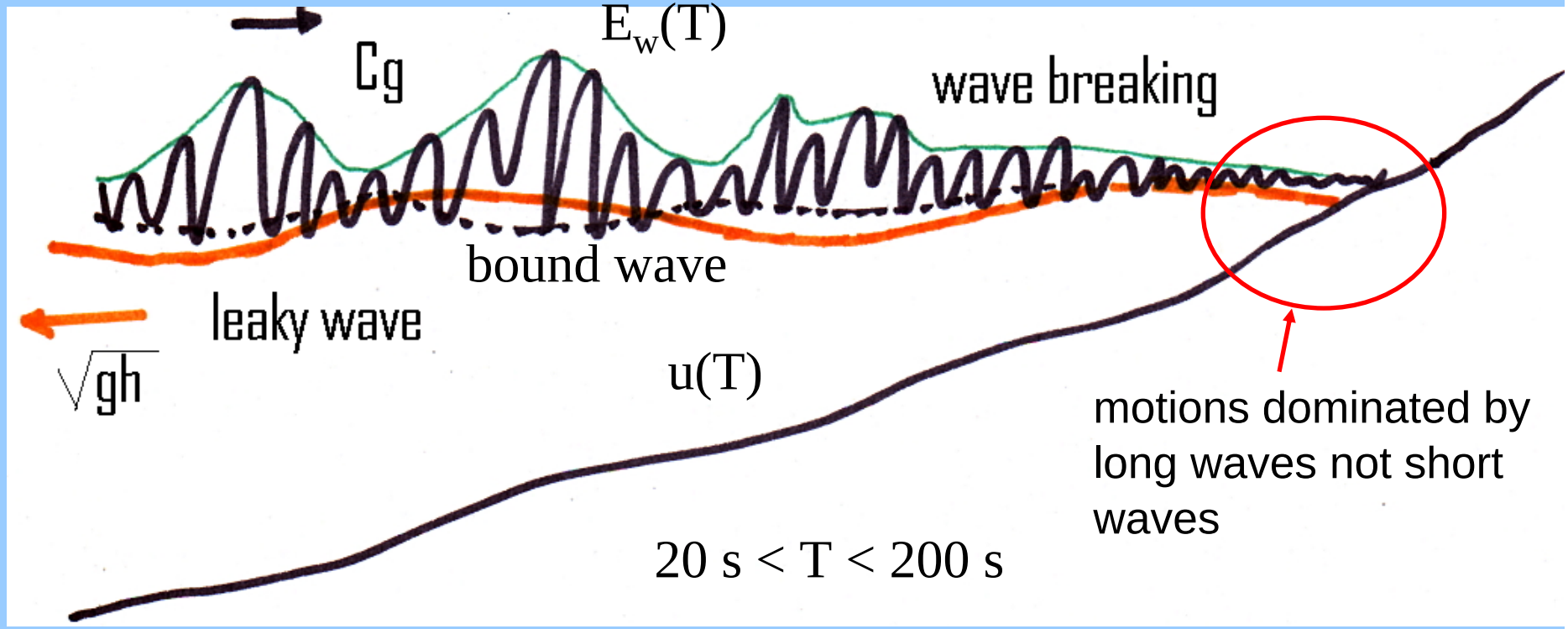
XBeach

Approach

- **Compiled code in modules**
- **Short-wave averaged but long-wave resolving modeling of waves, flow and morphology change in time-domain**
- **Swash and overwash motions**
- **Dune erosion, overwashing, breaching and full inundation**
- **Domain from outside surfzone to backbarrier**
- **Driven by boundary conditions from surge and spectral wave models**

XBeach

Principle sketch - physics



XBeach

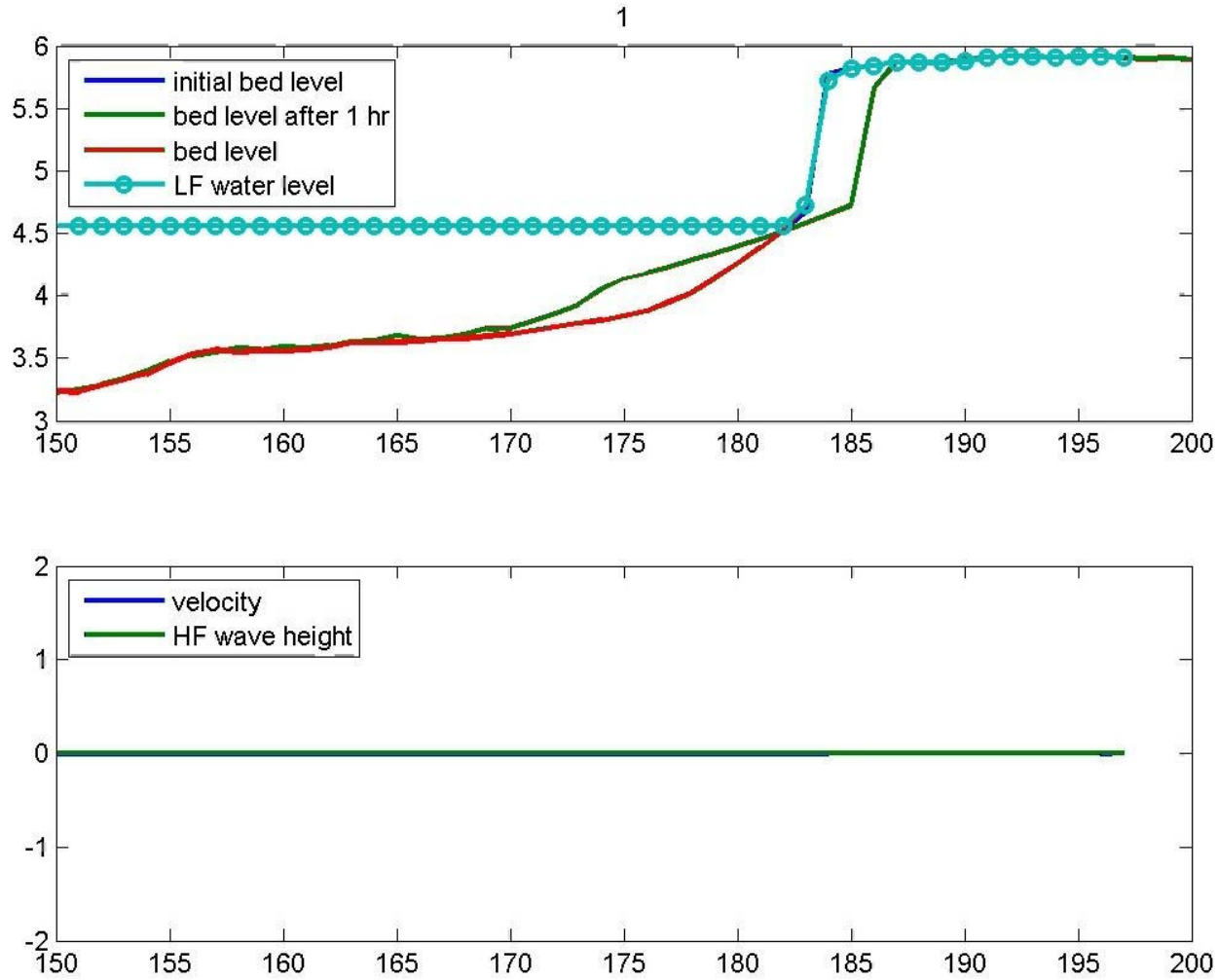
Sediment transport

- **Depth-integrated advection-diffusion equation**
- **Equilibrium concentration determined by Soulsby-van Rijn formulations**
- **Velocity includes seaward return flow**

$$\frac{\partial hC}{\partial t}+\frac{\partial hCu^E}{\partial x}+\frac{\partial hCv^E}{\partial y}+\frac{\partial}{\partial x}\left[D_h h\frac{\partial C}{\partial x}\right]+\frac{\partial}{\partial y}\left[D_h h\frac{\partial C}{\partial y}\right]=$$

$$=\frac{hC_{eq}-hC}{T_s}$$

XBeach Detailed beach process model plus avalanching



CSHORE

Approach

- Simple, Efficient, Wide Range of Verification
- Longshore Uniform Formulation
- Steady Formulation
- Shallow Water Hydrodynamics
- Probabalistic Representation of Sediment Transport
- Entrainment driven by Energy Dissipation
- Includes Wave and Current Transport
- Bed load and Suspended load

CSHORE

Suspended Sediment

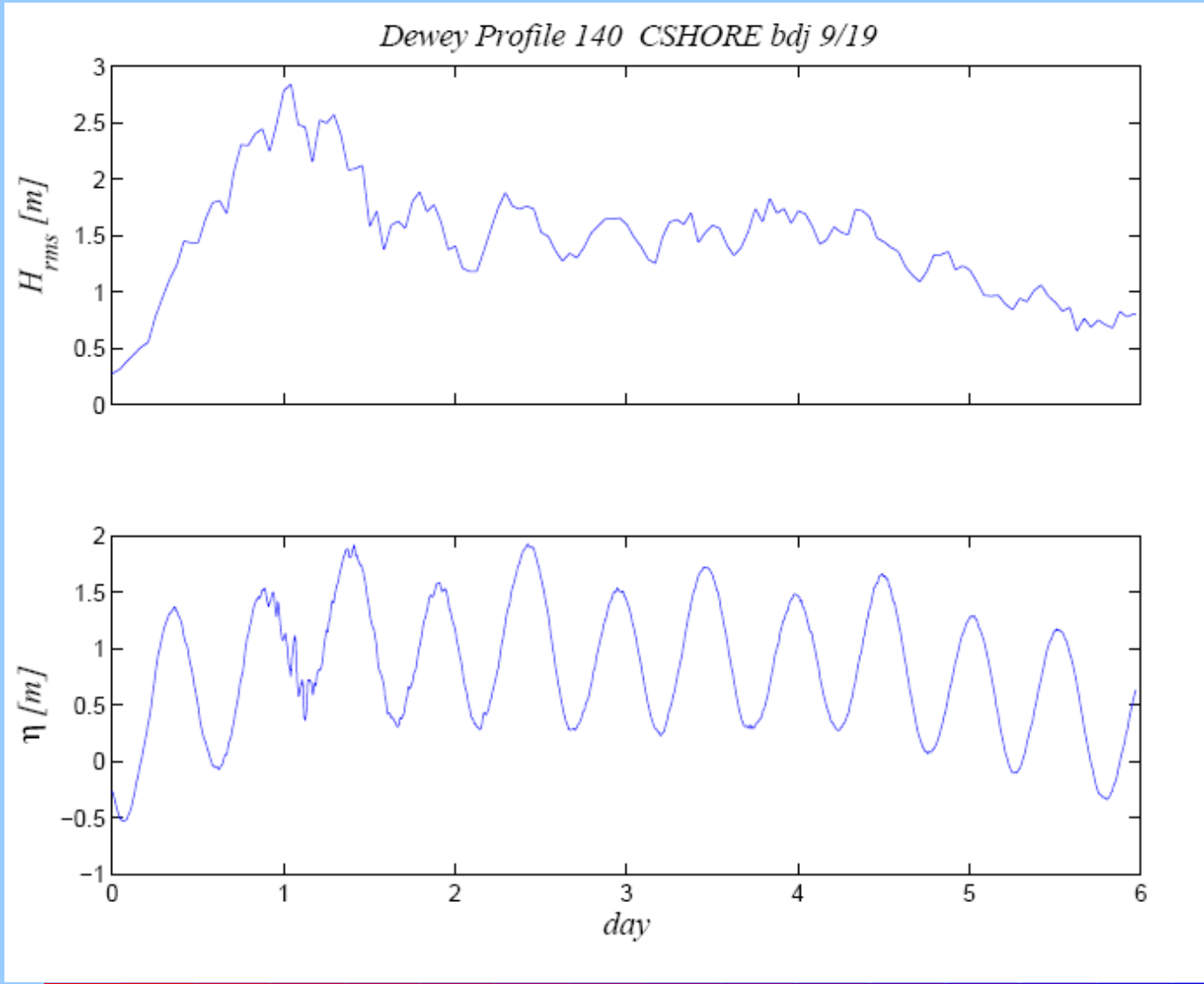
- Suspended sediment volume V_s per unit area is estimated as

$$V_s = \frac{e_B D_B + e_f D_f}{\rho g (s-1) w_f} P_s$$

- where $e_B = 0.005$ and $e_f = 0.01$.
- Probability P_s is estimated as the probability of u' exceeding sediment fall velocity



Typical Application (East Coast)



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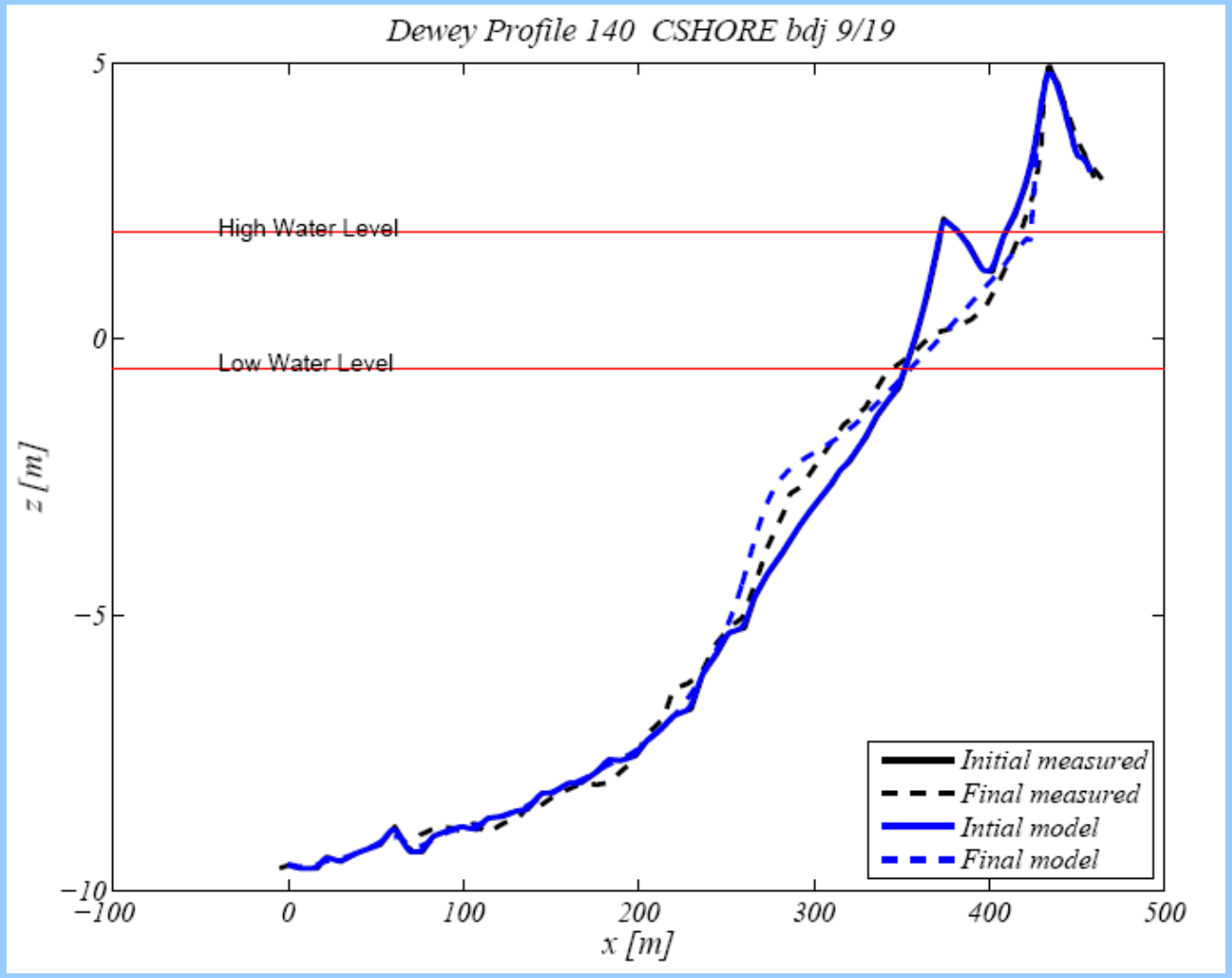
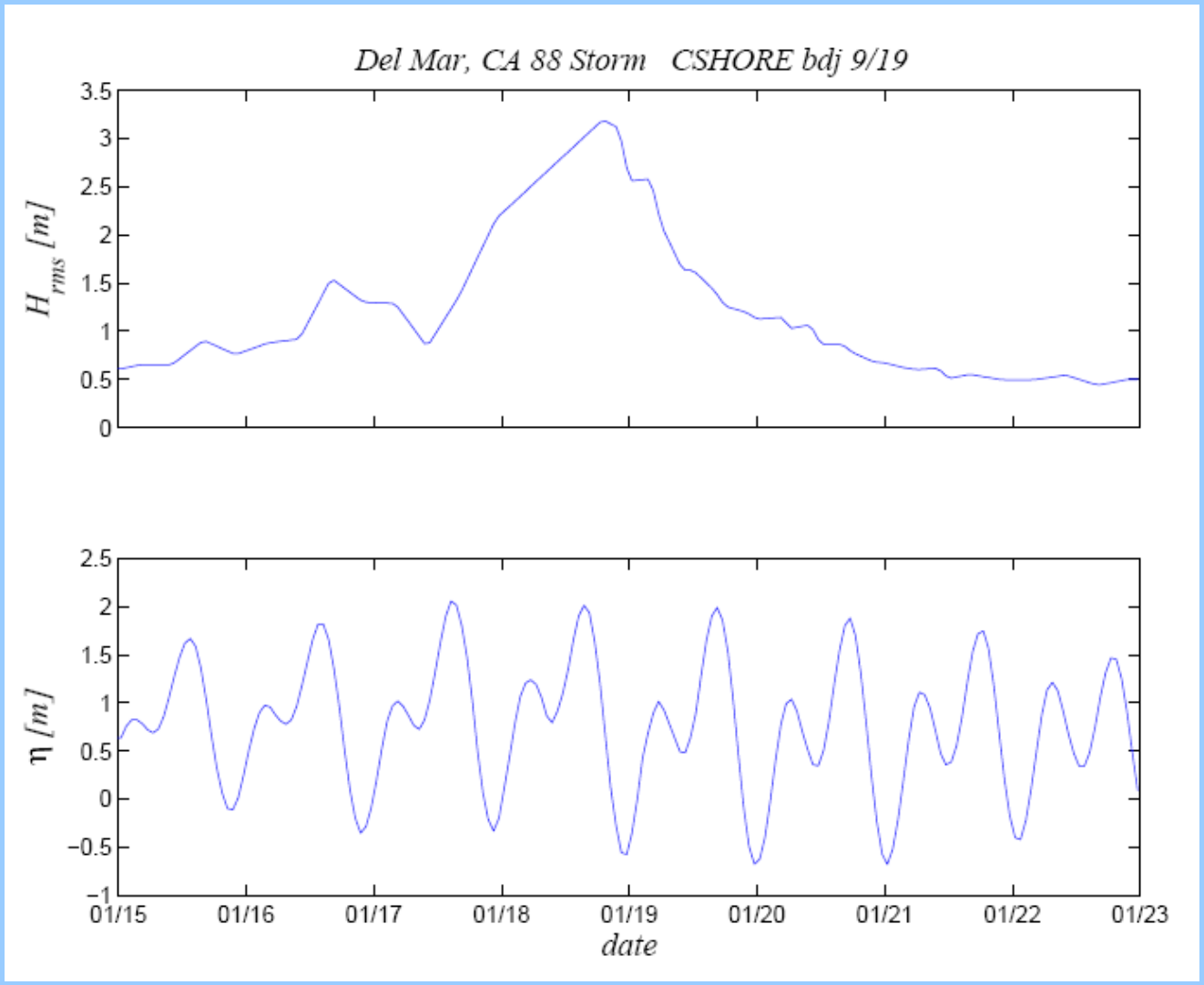


Typical Application (West Coast)



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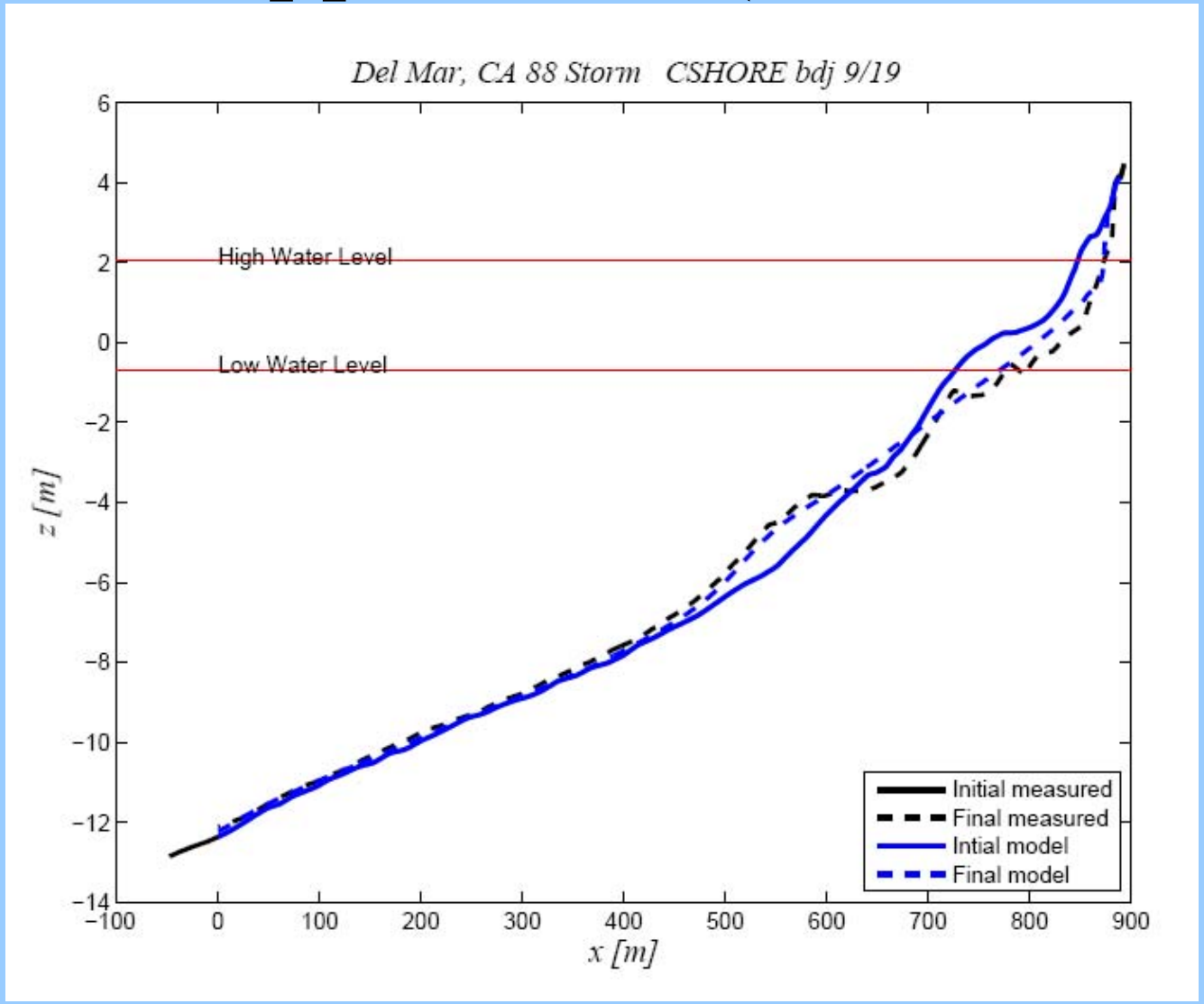
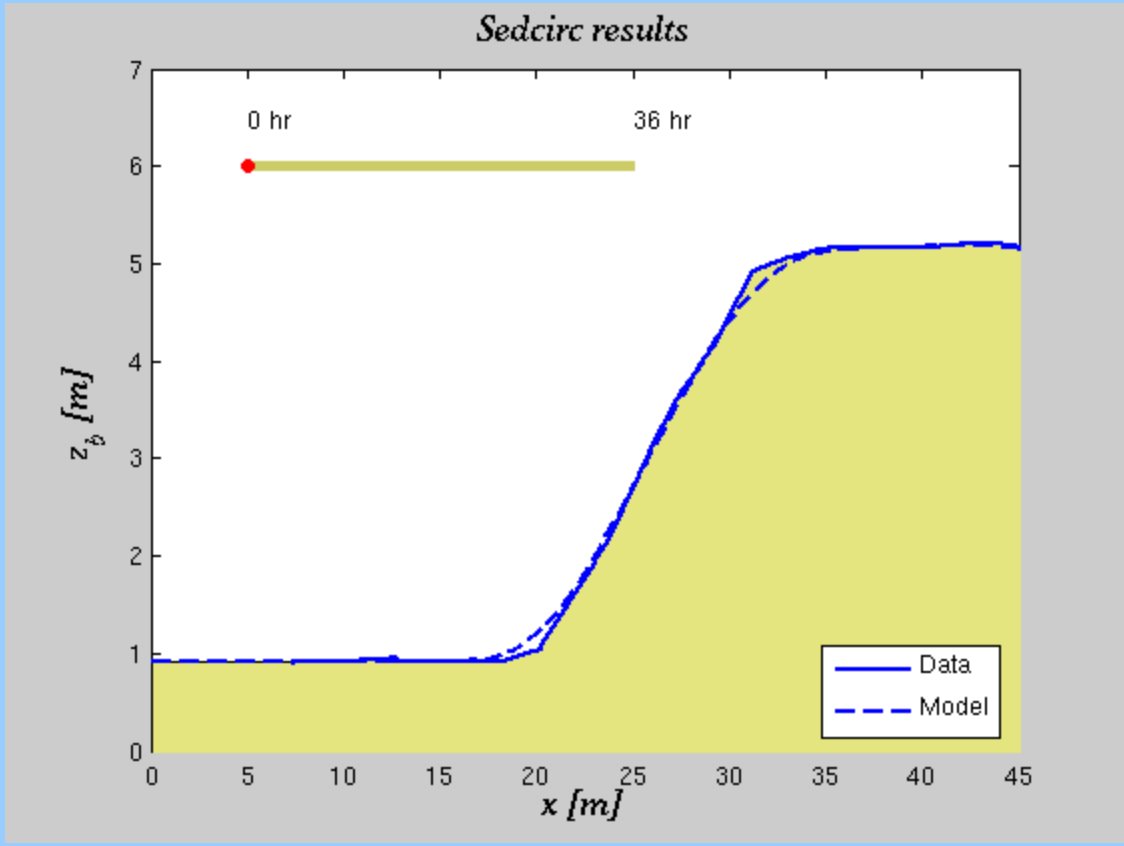


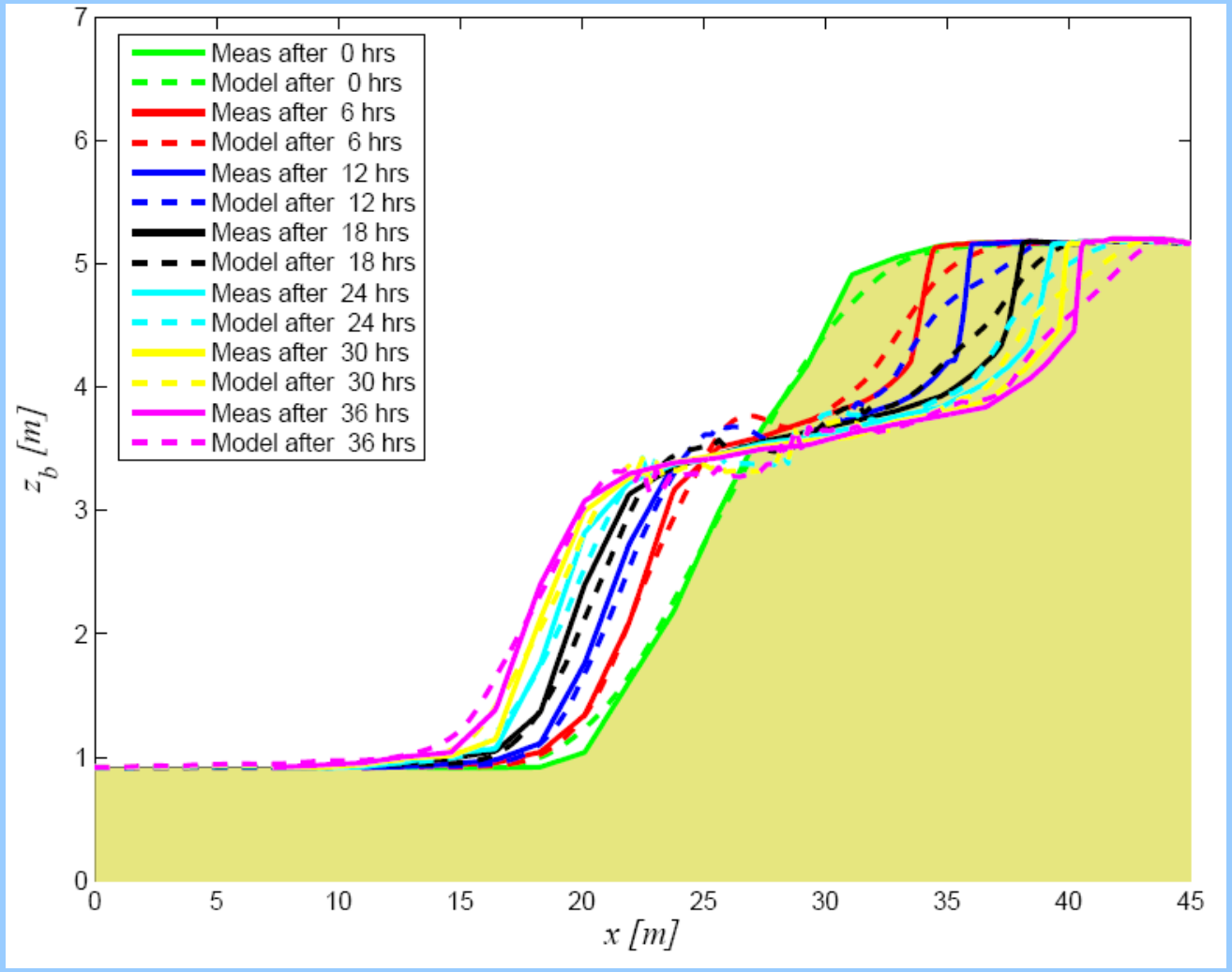
CSHORE

OSU


Sedcirc results
0 hr
36 hr
Data
Model
z_b [m]
x [m]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40
45

CSHORE

OSU

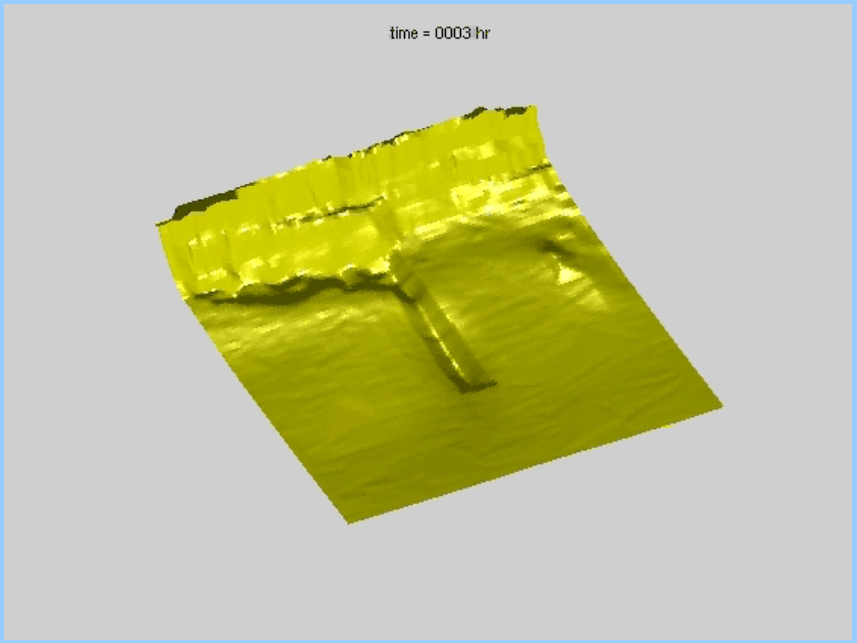

Meas after 0 hrs
Model after 0 hrs
Meas after 6 hrs
Model after 6 hrs
Meas after 12 hrs
Model after 12 hrs
Meas after 18 hrs
Model after 18 hrs
Meas after 24 hrs
Model after 24 hrs
Meas after 30 hrs
Model after 30 hrs
Meas after 36 hrs
Model after 36 hrs
z_b [m]
x [m]
0
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35
40
45

C2SHORE

Extension of CSHORE to 2DH

STWAVE + STCIRC + Sediment Transport Model

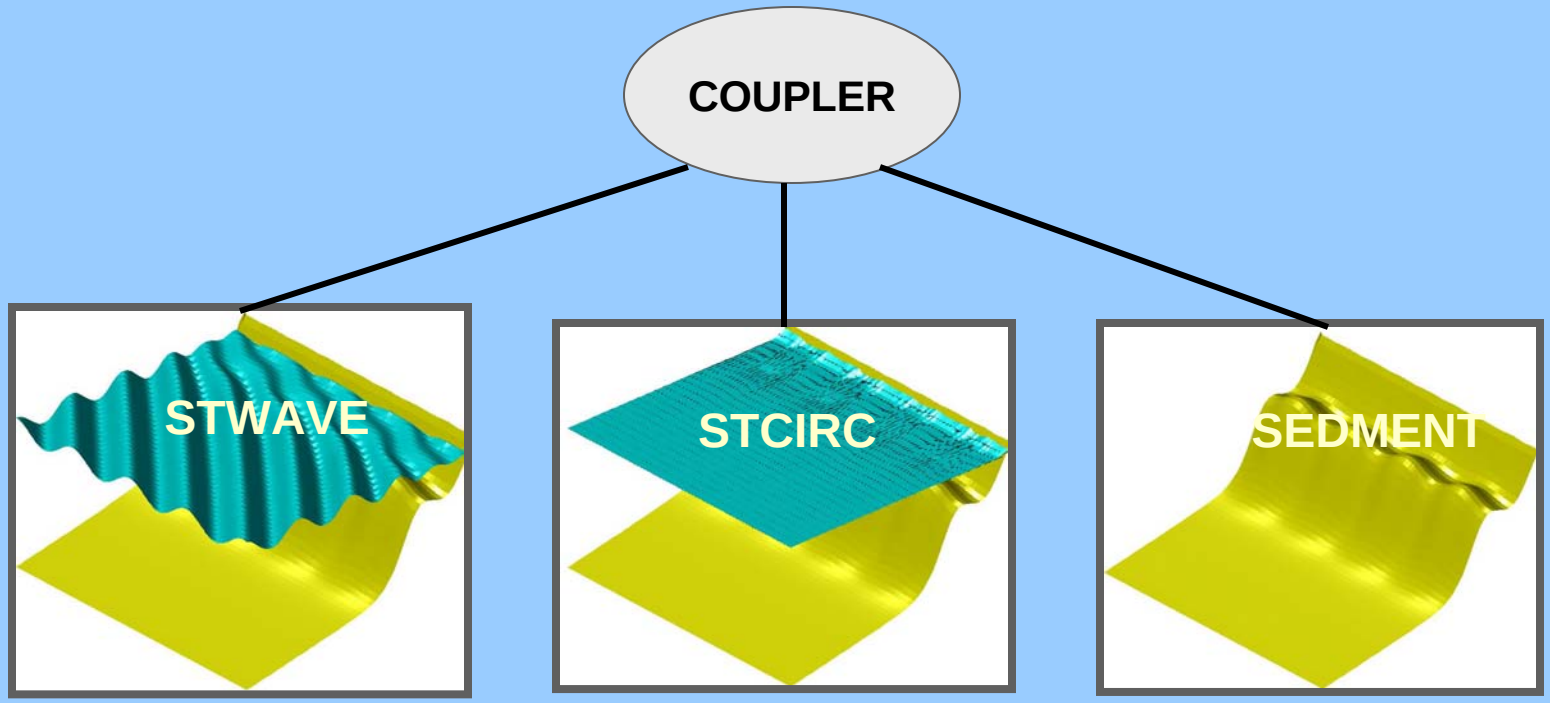
- Extension to 2DH Allows longshore variations, inlets, etc.
- Coupled wave, circulation, sediment transport, morphology



FRF During Isabel (model result)

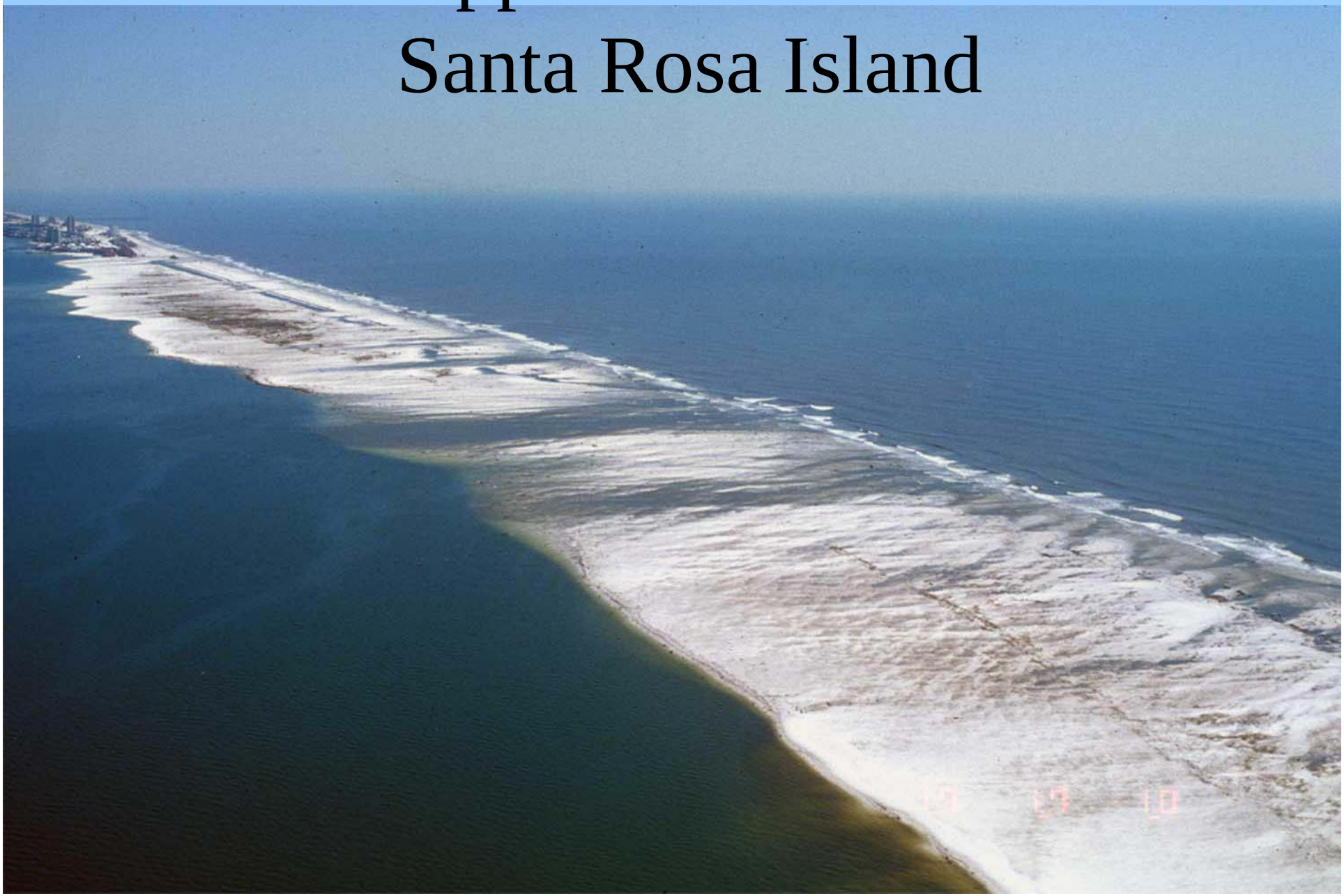
C2SHORE

Model Framework

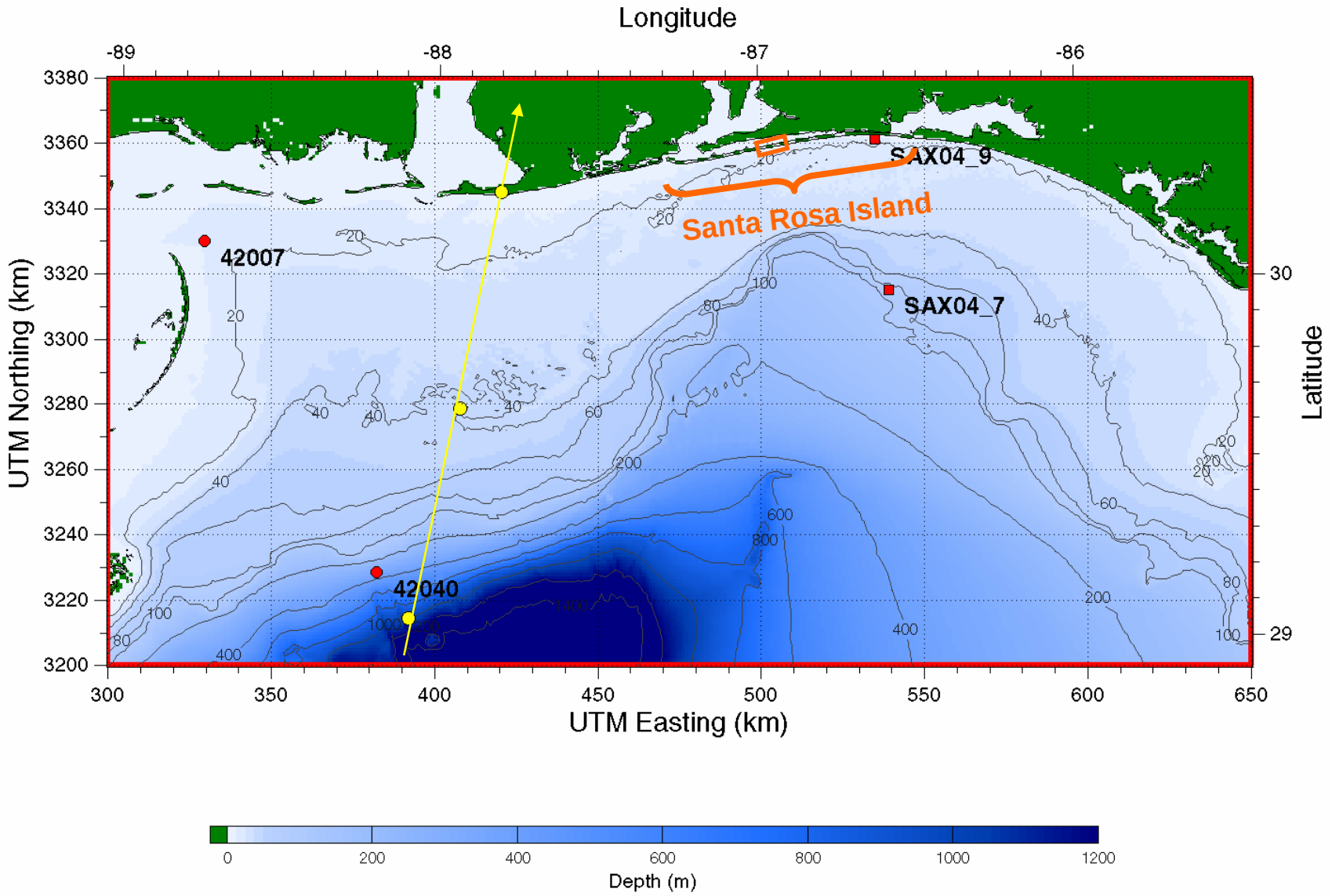


Transport algorithms are and extension, but framework is more flexible.

C2SHORE Application: Santa Rosa Island

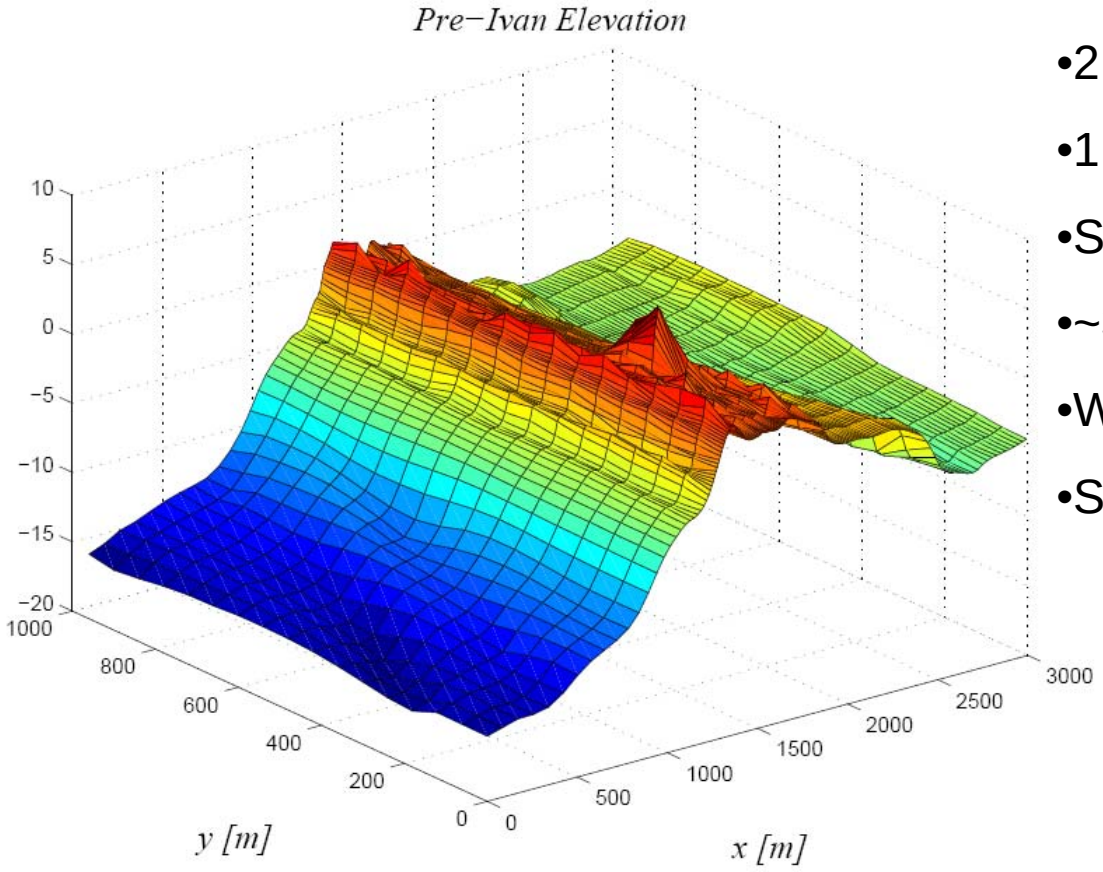


C2SHORE


Longitude
-89
-88
-87
-86
3380
3360
3340
3320
3300
3280
3260
3240
3220
3200
UTM Northing (km)
30
29
Latitude
300
350
400
450
500
550
600
650
UTM Easting (km)
SAX04_9
Santa Rosa Island
42007
SAX04_7
42040
0
200
400
600
800
1000
1200
Depth (m)

C2SHORE

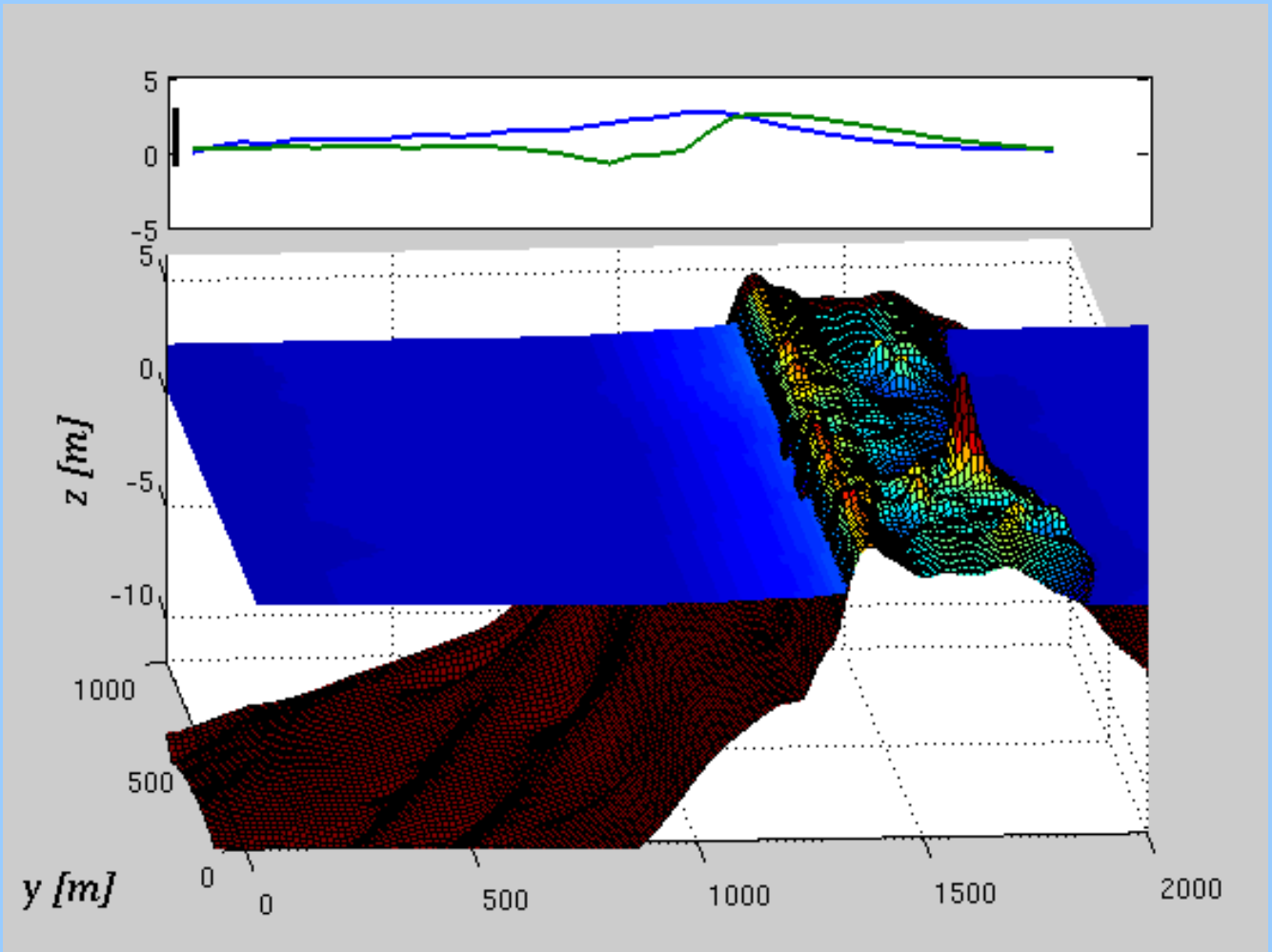
Model domain



- Square grid, dx = dy = 20m
- 2.5 km cross-shore
- 1 km longshore
- Steady runs every 20 min.
- ~30 min wall clock on single CPU
- Wall lateral BC, extended domain
- Standard *eff_B, eff_f, b*

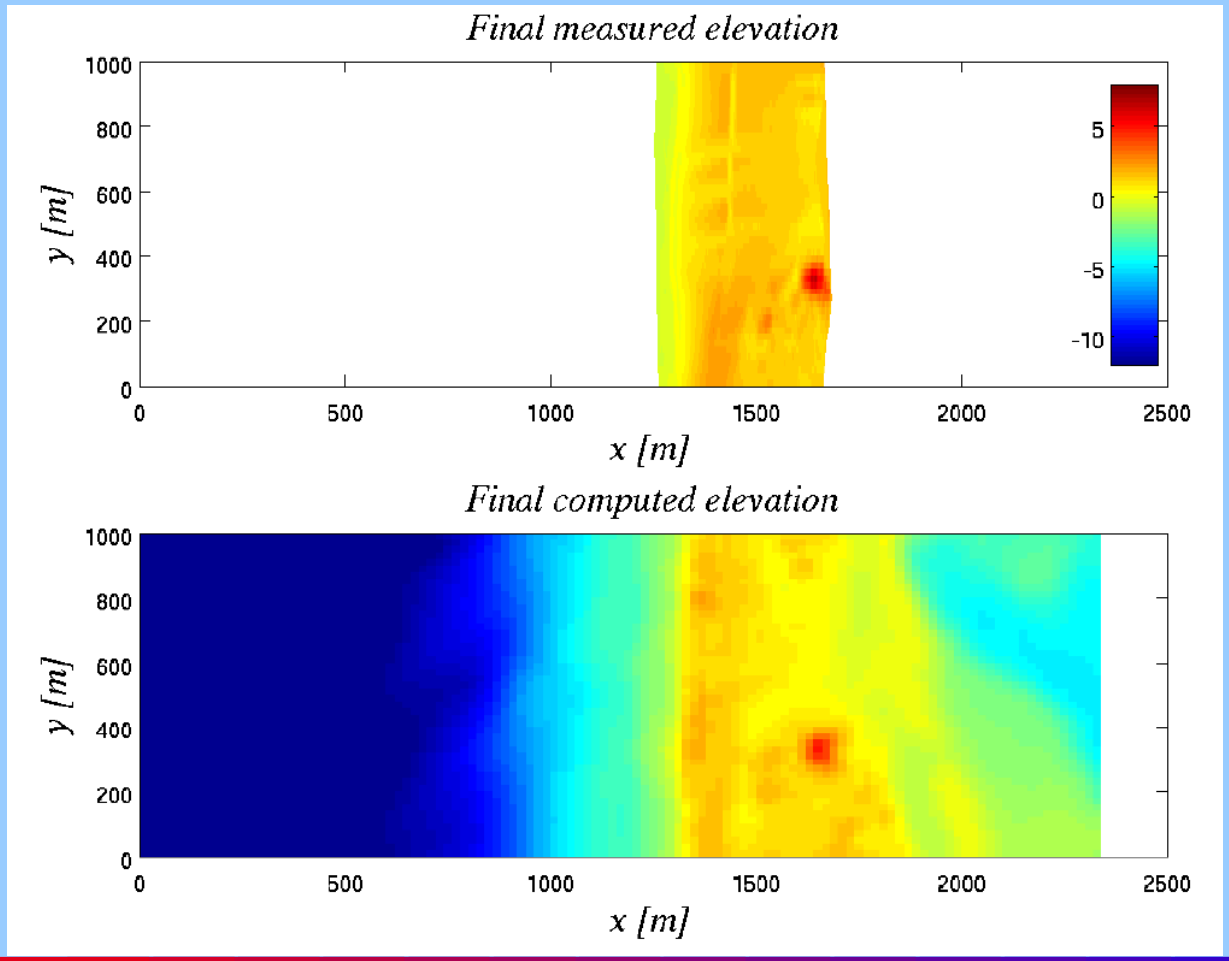
C2SHORE

Model Run

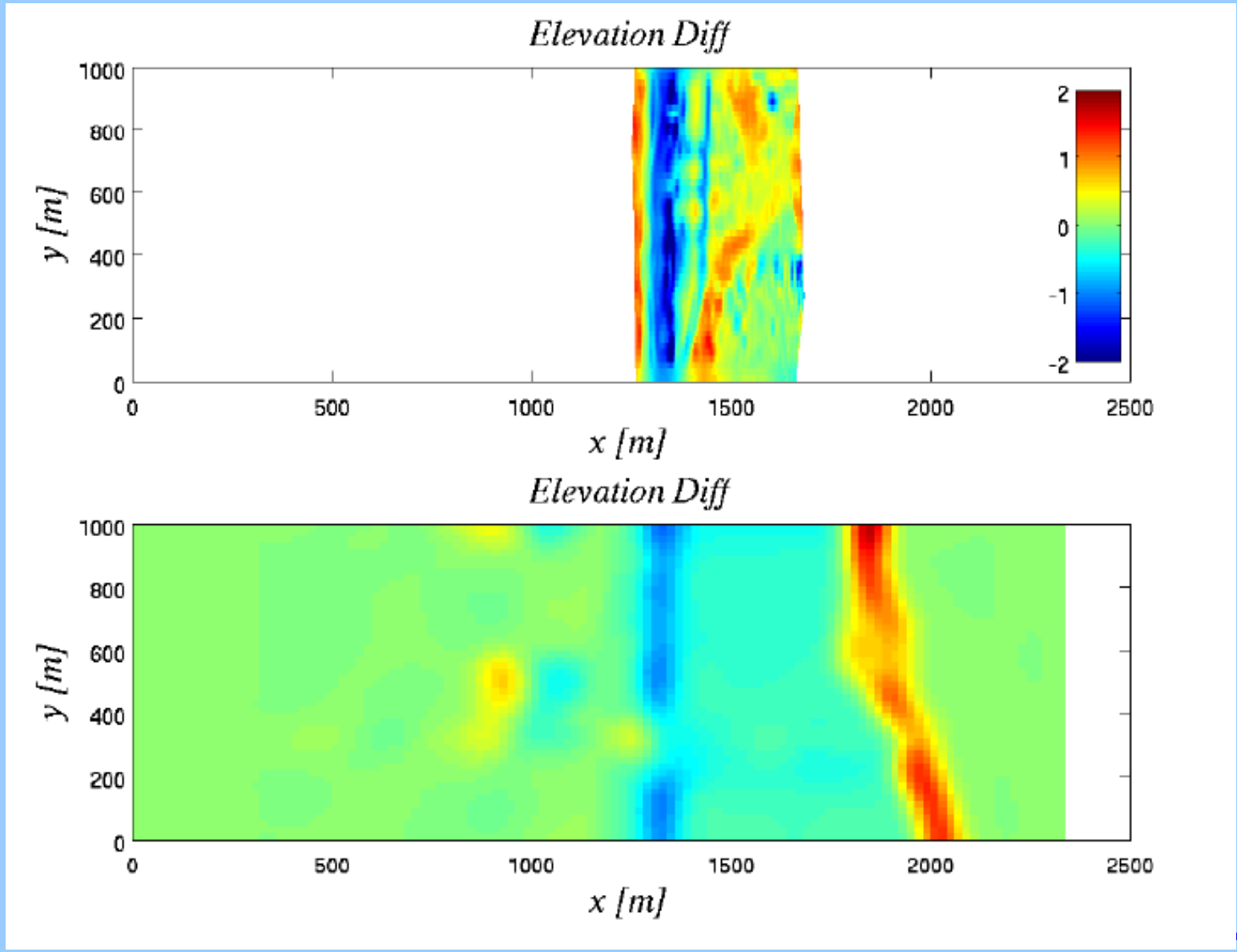


C2SHORE

Post Measured, Computed Bed



C2SHORE Post and Pre Difference



What does this reveal about C2SHORE?

- **Water levels? --- two m of discrepancy between basin-scale models**
- **Waves? --- no data**
- **Currents --- no data**
- **Bathymetry --- only pre-storm**

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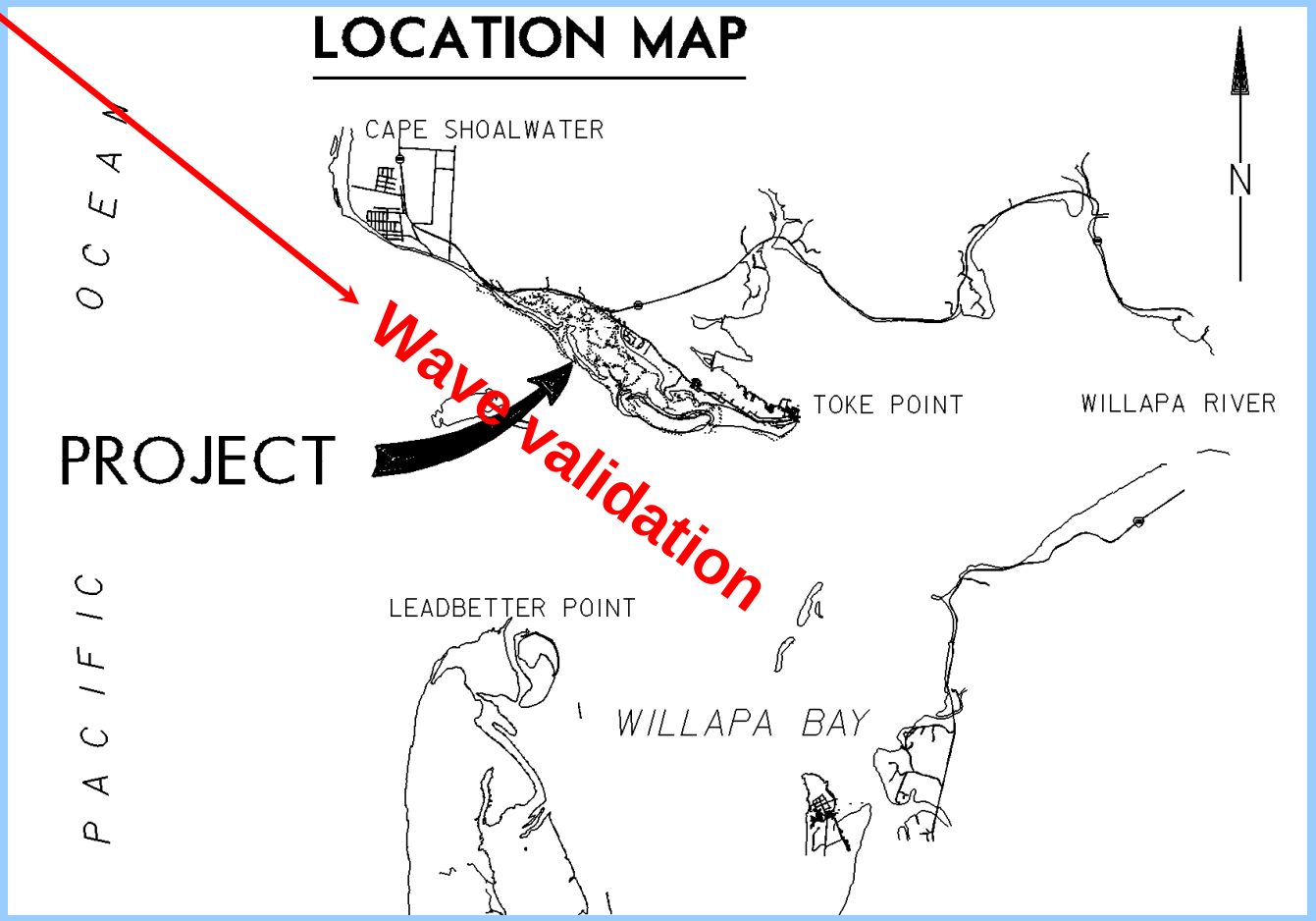
Revealed: C2SHORE is predicting morhpology change with some error, but why?

Data Needs

Waves

Currents



Offshore waves at boundary

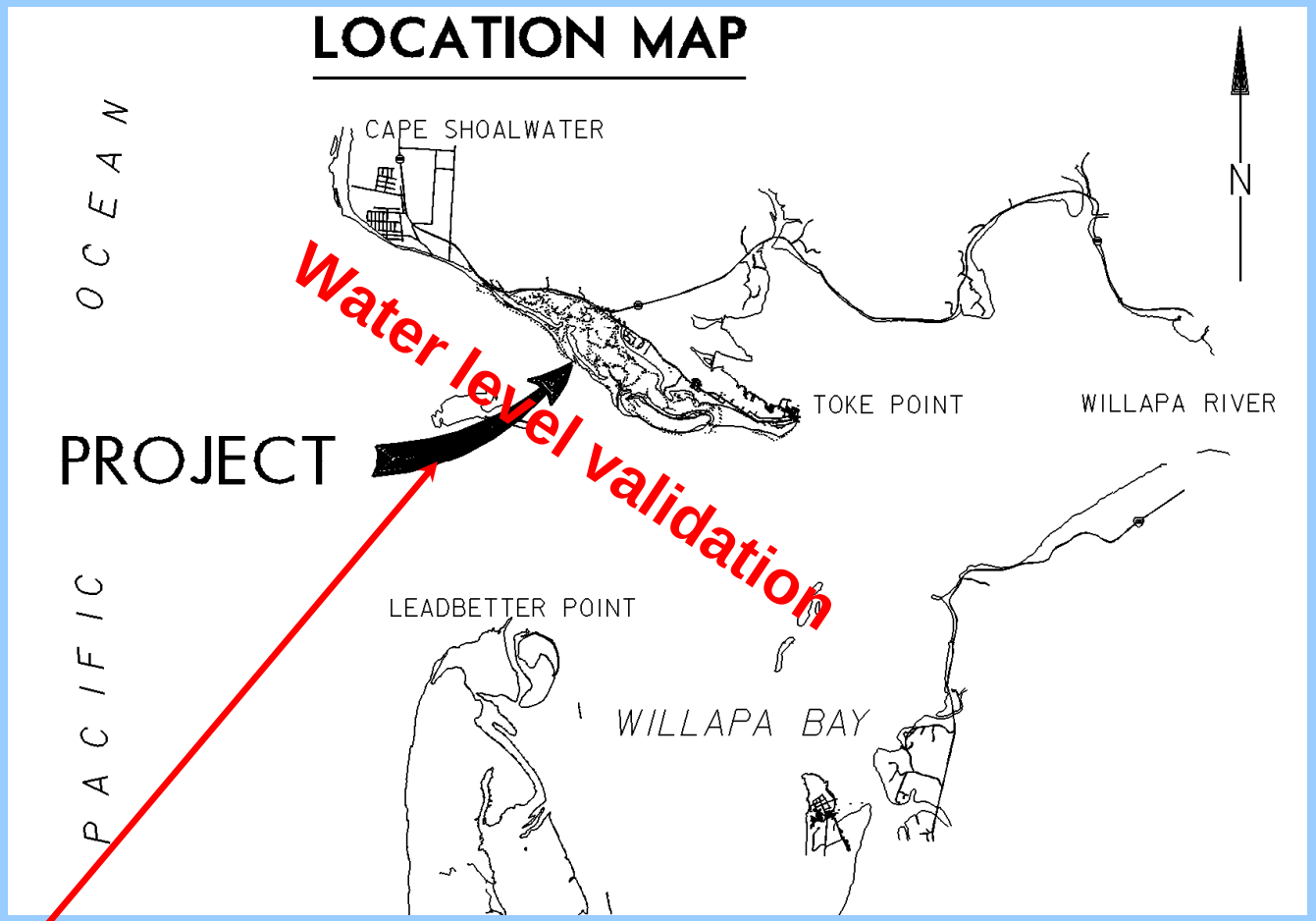
Water Levels

Geometry

Data Needs

Waves

Currents



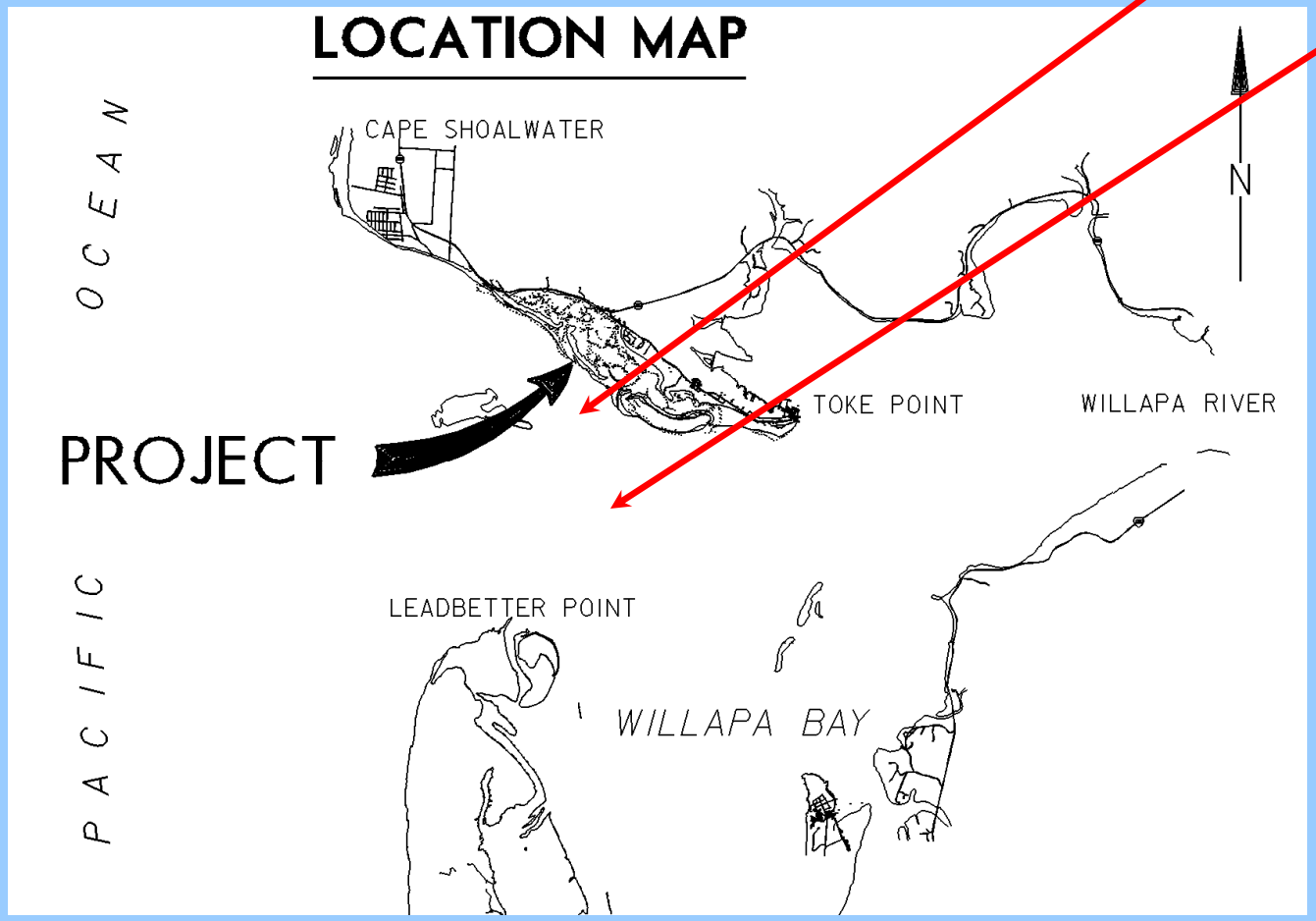
Water Levels

Geometry

Data Needs

Waves

Currents



Water Levels

Geometry

Data Needs

Waves

Currents

- **Sediment and underlying features**
- **Pre-storm conditions (topo + bathy + sed) at last minute**
- **Post-storm profiles shortly following**

Water Levels

Site &Geometry

A Joint Effort

- **A Willapa Bay model benefits District**
  - **A high resolution circulation Bay model**
  - **Detailed nearshore domain for Morphology**
  - **Some confidence with present tools**
- **Monitoring data benefits MORPHOS**
  - **High quality data of large events is needed**
  - **Complex system drives the technology**